

SPACE SCIENCES LABORATORY

Energetic Particle Flux Experiment

(IMP F & G)

January 28, 1965 - June 30, 1971

FINAL REPORT

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Principal Investigator: K.A. Anderson

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TABLE OF CONTENTS

Abstract	ii
I. Description of the Data Supplied to the National Space Science Data Center	1
II. IMP 4, 5 Major Computer Processing Programs	5
III. List of Publications Reporting Results From IMP-4 and 5 Satellites	7
IV. Papers Presented at Scientific Meetings Reporting Results From the IMP-4 and 5 Satellites	9
Table 1	2
Table 2	4

Abstract

This report summarizes the data reduction procedures and programs for analysis of the IMP F and G Energetic Particle Flux Experiments of the University of California. The IMP-F experiment contained two thin-window Geiger-Müller detectors and an ionization chamber while there were two IMP-G experiments, one with six Geiger-Müller detectors and an ionization chamber, and the other with two funnel mouthed channeltrons in a parallel plate electrostatic analyzer. These experiments measured particles in the energy range above 20 keV (IMP-F) and above ~ 5 keV (IMP-G).

The scientific results are summarized in the attached bibliography of publications. The data from these experiments were predominantly used for the study of low energy solar particles from flares.

Dr. R.P. Lin and Mr. R.E. McGuire participated in many of the IMP F & G studies while students in the Ph.D. program.

I. Description of the Data Supplied to the National Space Science
Data Center

The IMP-4 data was supplied to the National Space Science Data Center in the form of 24 hour plots (1 inch/hour) of the counting rate of the three detector channels. These plots were generated by FPLT24 (described in section II).

The IMP-5 data was supplied in the form of magnetic tapes. These were produced by the CDC 6600 program S1 EDIT written by G. Pitt and G. Sessler. The program in part checked the timing information for consistency, removed redundant data due to receiving station overlaps and calculated corrected counting rates for the GM detectors and counting rate for the Ion Chamber. An output tape containing the rates and refined trajectory data was produced for each orbit. These tapes were then merged so that five orbits were contained on one reel. The tapes were recorded at 800 bpi, in odd parity (binary), multifile with two file marks to indicate the end of information. Each file contains the data from one 24 hour period. Table 1 describes the format in detail. Table 2 gives the dead time factors used in calculating the GM corrected counting rates.

Table 1

IMP-5 Edited Tape Format

<u>Word</u>		<u>Format</u>
1	Day	Integer
2	Time in Ms	I
3	Psuedo sequence count	I
4	ID or E_2 counting rate in CTS/sec	Floating point
5	ID or P_2 counting rate in CTS/sec	F
6	IC counting rate in CTS/sec	F
7	E_1 or E_3 counting rate in CTS/sec	F
8	P_1 or P_3 counting rate in CTS/sec	F
9	IC counting rate in CTS/sec	F
Words 10-108 repeat words 1-9 for a total of 12 sequences		
109	Orbit day	I
110	Ms of day	I
111	Geomagnetic latitude (MLAT)	F
112	Satellite distance in Km	F
113	X_{SE}	F
114	Y_{SE}	F
115	Z_{SE}	F
116	X_{SM}	F
117	Y_{SM}	F
118	Z_{SM}	F
119	McIlwain L parameter	F
120	Ecliptic Longitude (ELONG) in degrees	F
121	Solar Magentospheric Latitude (SMLAT) in degrees	F

Notes

1. $\text{ELONG} = \tan^{-1} \frac{Y_{\text{SE}}}{X_{\text{SE}}}$
2. $\text{SMLAT} = \tan^{-1} \frac{Z_{\text{SM}}}{\sqrt{X_{\text{SM}}^2 + Y_{\text{SM}}^2}}$
3. ID is indicated by a word equal to -1.(floating point).
4. Missing data is indicated by a word of all bits on.
5. All words are in CDC 6000 series standard 60 bit integer or floating point format.

Table 2

Counter	Dead Time Factor (μs)
E1	75
E2	100
E3	110
P1	40
P2	95
P3	107

The formula for calculating the corrected counting rate is as follows:

$$R = \frac{R_o}{1 - \tau R_o}$$

where

R = corrected rate

R_o = uncorrected (raw) counting rate

τ = dead time factor for the counter in seconds

II. IMP 4, 5 Major Computer Processing Programs

The following is a description of the major computer programs written to process the IMP-4 and IMP-5 UCAL experimental data. Although slight variations may exist between the version for the different experiments they are similar enough to describe as a whole.

1. RATE Program

The RATE programs served as the initial processing step on the GSFC supplied experimental data tapes. They produced printout (and later microfilm) containing raw counts and counting rates as seen by the experimental detectors. They also produced cards describing the quantity and in some sense the quality of the data covered. The programs were written by Barbara Watson for CDC 6000 System.

2. DATA CO F and G

The DATA CO programs produced Cal-Comp plots showing the amount of time covered by each file on the GSFC supplied tapes. Input is from cards produced by the corresponding RATE program. The following descriptions apply to IMP-4 programs only.

3. FPLT24 and FPLT6

These programs produce 1 inch/hour and 4 inch/hour by 5 cycle semi log plots of the GM and ion chamber outputs. The 24 hour plot serves as the primary display of the IMP-4 experimental data. The programs were written for CDC 6000 series systems by Maria Roberts in June, 1967.

4. FV RATE

This program calculates corrected rates and a simple running average of the corrected rates for the IMP-4 GM counter. It additionally calculates the ion chamber rate and various spectrum parameters. The program was written by George Pitt in July, 1967.

The following descriptions apply to IMP-5 programs only.

5. S1 EDIT

The S1 EDIT program served as a basic display of the IMP-5 GM and ion chamber data. It produced two 24 inch by 5 cycle semi log Cal-Comp plots for each 24 hours of data. In addition it produced an edited tape containing continuous, non-redundant, time corrected experimental outputs. These tapes were used as input to further analysis programs and later supplied to the National Space Science Data Center. S1 EDIT was written by Gladys Sessler and George Pitt in June, 1969.

6. IMP-5 plotting/averaging system

The system consisted of a collection of programs written by Carl Wittnebert in February, 1970. It produced Cal Comp plots of averaged data. The average period as well as the plot scales were completely variable. Various detectors outputs could be grouped together and ratios of various detector outputs could be plotted. Input to the system was the edited tapes produced by the S1 EDIT program.

7. S2 RATE

The S2 RATE program produced a listing of the raw counts and observed counting rates for the IMP-5 S2 experiment. The listing was non-fill points. The program was written by G. Pitt and later modified by C. Wittnebert in November, 1969.

III. List of Publications Reporting Results From IMP-4 and 5 Satellites

- Alvarez, H. F. Haddock, and R.P. Lin, Evidence for electron excitation of type III radio burst emission, *Solar Phys.*, 26, 468, 1972.
- Anderson, K.A., Electrons and protons in long-lived streams of energetic solar particles, *Solar Physics*, 6, 111, 1969.
- Anderson, K.A., S.R. Kane and R.P. Lin, Fast electrons in solar flares, International Seminar on the Problem of Cosmic Ray Generation on the sun, Leningrad, USSR, December, 1970, (SSL Series 12, Issue 7).
- Anderson, K.A. and R.P. Lin, Information on the University of California experiments in the Explorer 33 and 35 satellites (Lunar Anchored IMP's) and the Explorer 34 and 41 satellites (IMP's 4 and 5), UCB SSL Technical Report, Series 11, Issue 89, 1970.
- Anderson, K.A., Particle Acceleration by Shock Waves in the Solar System, to be published in Proceedings of the Leningrad Seminar on Generality of Particle Acceleration, Leningrad, USSR, August, 1972.
- Kane, S.R. and R.P. Lin, Location of the electron acceleration region in solar flares, *Solar Phys.*, 23, 457, 1972.
- Lin, R.P., The emission and propagation of ~ 40 keV solar electrons, Proc. XI Int. Conf. on Cosmic Rays, Budapest, 1969 *Acta Physica Acad. Sci. Hungaricae*, 29, Suppl. 2, 669, 1970.
- Lin, R.P., Observations of scatter-free propagation of ~ 40 keV solar electrons in the interplanetary medium, *J. Geophys. Res.*, 75, 2583, 1970.
- Lin, R.P., The emission and propagation of ~ 40 keV solar flare electrons
I. Relationship of ~ 40 keV electron to energetic proton and relativistic electron emission by the sun, *Solar Phys.* 12, 266, 1970.
- Lin, R.P., The emission and propagation of ~ 40 keV solar flare electrons
II. The electron emission structure of large active regions, *Solar Phys.* 15, 453, 1970.

- Lin, R.P. and H.S. Hudson, 10-100 keV electron acceleration and emission from solar flares, *Solar Phys.*, 17, 412, 1971.
- Lin, R.P., Acceleration of 10-100 keV electrons in solar flares, International Seminar on the Acceleration of Particles in Near-Earth and Interplanetary Space, Galaxy and Metagalaxy, Leningrad, USSR, July 13-15, 1971 (SSL Series 12, Issue 63).
- Lin, R.P., Energy spectra of solar flare electrons, Proc. 1971 XII International Cosmic Ray Conference, Hobart, Tasmania, Australia, August, 1971.
- Lin, R.P., Acceleration of electrons in Solar Flares, to be published in the Proceedings of the Solar Terrestrial Relations Conference, Calgary, Canada, August 28-September 1, 1972.
- Lin, R.P., The relationship of solar flare electrons to the flare flash phase and type III radio bursts, to be published in the "High Energy Phenomena on the Sun," the Proceedings of the Symposium on High Energy Phenomena on the Sun held at Goddard Space Flight Center, September, 1972.
- Lindgren, S.T., The solar particle events of May 23 and May 28, 1967, *Solar Phys.*, 4, 338, 1968.
- Palmer, I.D. and R.P. Lin, The position and size of radio sources associated with solar electron events, to be published in "High Energy Phenomena on the Sun," the Proceedings of the Symposium on High Energy Phenomena on the Sun held at Goddard Space Flight Center, September, 1972.
- Palmer, I.D. and R.P. Lin, The coronal site of a type III burst as a source of interplanetary electrons, *Proc. Astron. Soc., Australia*, 2, 101, 1972.

IV. Papers Presented at Scientific Meetings Reporting Results From
the IMP-4 and 5 Satellites

Lin, R.P., Fluxes of ~ 40 keV electrons associated with solar active regions, AGU, Washington, D.C., April, 1969.

Roelof, E.C. and R.P. Lin, Coronal storage and interplanetary propagation of low energy solar particles, AGU, San Francisco, California, December, 1969.

Lin, R.P., Observations of solar flare electrons, invited review paper, AGU, San Francisco, California, December 1970.

Lin, R.P., J.R. Wang, and L.A. Fisk, Scatter-free electron propagation in the interplanetary medium, AGU, San Francisco, California, December, 1972.

McGuire, R.E., K.A. Anderson, L.M. Chase, R.P. Lin, and J.E. McCoy, Particle observations during the passage of the interplanetary shock of May 15, 1972, AGU, San Francisco, California, December, 1972.

Wang, J.R., L.A. Fisk and R.P. Lin, Observations of the scatter-free solar-flare electrons in the energy range 20-1000 keV, 12th International Conference on Cosmic Rays, Hobart, Tasmania, Australia, August, 1971.

Lin, R.P., Energy spectra of solar flare electrons, 12th International Conference on Cosmic Rays, Hobart, Tasmania, Australia, August, 1971.

Lin, R.P. and K.A. Anderson, Solar electron events in mid-1967, AGU, San Francisco, California, December, 1968.

Lin, R.P., The emission and propagation of ~ 40 keV solar electrons, 11th International Conference on Cosmic Rays, Budapest, Hungary, 1969.

Anderson, K.A., Low energy electrons and protons from the sun, 11th International Conference on Cosmic Rays, Budapest, Hungary, 1969.